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ABSTRACT

This study used the "double easy-to-hard" paradigm to examine the hypothesis that the class inclusion (CI) task should be equivalent in relational complexity to the transitive inference (TI) problem. Participating in the study were 64 girls and 50 boys, with a mean age of 8 years, 6 months. Stimuli for easy versions of the tasks were displayed visually. A computer was used for presenting auditory stimuli and for recording reaction times (RT). Children were given the CI and TI tasks approximately one week apart in counterbalanced order. Subjects were first given an easy version of the primary reasoning task, then a dual task (easy version presented jointly with a secondary, probe RT task), followed by a hard aurally-presented version of the primary task. The probe RT task was presented alone in the first session. CI problems consisted of presenting a superordinate class followed by two subclasses differing in number of items. The TI task was comprised of 3-term series problems consisting of two premises followed by a binary choice option. Findings indicated that various predicted relationships within and across tasks were significant for boys, suggesting that the CI and TI task are capacity demanding and that they impose similar processing loads. However, some dissociations between CI and TI tasks suggest that inclusive reasoning may be qualitatively different from that of the TI problem. None of the predicted correlations were significant for girls; their performance suggested the adoption of a strategy that reduced capacity demands of both reasoning tasks. (KB)

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ASSESSING RELATIONAL COMPLEXITY IN HIERARCHICAL REASONING: A DUAL-TASK APPROACH

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Assessing Relational Complexity in Hierarchical Reasoning: A Dual-Task Approach

According to Halford (1993), the class inclusion (CI) task should be equivalent in relational complexity to the transitive inference (TI) problem. We tested this hypothesis by making use of the "double easy-to-hard" paradigm (Halford, 1993), which is an extension of a modified dual-task approach developed by Hunt and Lansman (1982; see also Lansman & Hunt, 1982). Although their modification of the standard dual-task approach has been successfully adapted for use with children (Foley & Berch, 1997; Halford, Maybery, & Bain, 1986; Rogers & Berch, 1991), the double easy-to-hard extension designed by Halford has not been employed to date in any published empirical study of cognitive development.

Method

A total of 114 children, 64 girls and 50 boys, with a mean age of 8 years, 6 months (range = 7 years, 8 months to 10 years, 2 months) participated in this experiment. The stimuli for easy versions of the reasoning tasks were displayed visually. A computer was used for presenting the auditory stimuli (tones and sentences) and for recording reaction times (RTs). Children were administered the CI and TI tasks in two separate sessions (approximately one week apart), with order counterbalanced. Within each session, they were first administered an easy version of the primary reasoning task, then a dual task (easy version presented jointly with a secondary, probe RT task), followed by a hard version of the primary task (aural administration only). The probe RT task was presented alone in the first session for all children. The CI problems (see Figure 1) consisted of the presentation of a superordinate class followed by two subclasses differing in the number of items (e.g., "Here are some balls; some are soccer balls and some are basketballs. Are there more balls or more basketballs?"). The TI

task (see Figure 2) was comprised of 3-term series problems consisting of the presentation of two premises followed by a binary choice option (e.g., "The box of grapes is above the box of apples; the box of bananas is above the box of grapes. Which box is above the other, the box of apples or the box of bananas?").

Results

Because of unanticipated gender differences (described in part below), the main analyses presented here are based only on the results of the boys. Table 1 shows the means and SDs for the nine dependent measures. For both sets of tasks, several crucial assumptions concerning dual-task conditions were satisfied (see Table 2), thereby permitting individual differences analyses to be carried out. The various types of predicted relationships (both within- and cross-task) emerging from the double easy-to-hard paradigm are illustrated in Figure 3. All five correlations were significant: between 1) CI dual-task RT and the CI hard primary task (-.43, $p < .0001$); 2) TI dual-task RT and the TI hard primary task (-.35, $p < .0001$); 3) the CI and TI hard primary tasks (+.39, $p < .0001$); 4) CI dual-task RT and the TI hard primary task (-.31, $p < .0005$); and 5) TI dual-task RT and the CI hard primary task (-.35, $p < .0001$). (Neither of the two within-task correlations nor any of the three cross-task correlations were significant ($p > .05$) for the girls, who upon further analysis seem to have adopted a strategy that reduced capacity demands of both reasoning tasks.) Finally, the two cross-task, second-order partial correlations for the boys (see Figure 4 for the logic underlying these) were both significant (-.28 and -.29, $p < .005$).

Discussion

Taken together, the correlational results (for the boys) indicate that not only are the CI and TI tasks both capacity demanding, but they impose similar processing loads, as predicted

by Halford's theory of relational complexity. Nevertheless, additional analyses yielded several dissociations between the CI and TI tasks. For example, the correlation between the easy and hard versions of the CI primary task (.92) was not only significantly stronger than the correlation between the easy and hard versions of the TI primary task, but also much stronger than the comparatively modest correlations typically found using the easy-to-hard approach. This finding is most likely attributable to the *dependent* dimension of inclusiveness inherent in hierarchical classification, whether a hard or easy version of the CI task is administered. As such, we contend that the relational complexity of this kind of reasoning may be qualitatively different from that of the transitive inference problem, requiring the resolution of inconsistencies in the structure mapping phase of relational reasoning.

Of course, this process did not differentially influence capacity demands for the CI and TI tasks in our study, perhaps due to our 8-year-olds having had sufficient experience with hierarchical relations to easily develop an appropriate mental model. Nevertheless, it is quite possible that younger children (i.e., 5- and 6-year-olds) would need to allocate additional processing resources to develop a mental model of inclusive relations. This view is consistent with the ideas of Blewitt (1994), who has postulated a sequence of four stages in the development of class inclusion reasoning. She suggests that this sequence begins with comprehension of the rudimentary (independent) aspects of a class inclusion task, and then gradually progresses to the acquisition of the concept of inclusiveness. To the extent that this hypothesis is correct, one would expect to find nonsignificant cross-task correlations with 5- and 6-year-olds. However, it remains to be seen whether the double easy-to-hard paradigm can be successfully adapted for use with young children.

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Table 1

Means (and SDs) For Nine Dependent Measures Reflecting Accuracy and Reaction Times (in ms) for Boys

	Dependent measures				
Session	Easy Alone	Dual-Task Easy	Hard Alone	Dual-Task RT	Probe RT Alone
CI					
M	.72	.72	.63	604	
SD	(.40)	(.38)	(.39)	(327)	237
TI					(60)
M	.83	.77	.57	705	
SD	(.18)	(.19)	(.21)	(344)	

Note. CI = Class Inclusion tasks; TI = Transitive Inference tasks. The probe RT alone task was only administered during the first session.

Table 2

Basic and Double Easy-to-Hard Dual-Task Assumptions and the Corresponding Tests

Assumption	Description	Test
Basic		
1	Under dual-task conditions, the easy primary task and the secondary task must compete for a limited amount of processing resources.	The mean RTs for dual-task condition must be significantly slower when compared with the probe RT alone condition.
2	While performance on the probe RT task alone should primarily be data limited (i.e., increased allocation of resources will not yield improvement), performance in the probe RT task under dual-task conditions should be both data limited and resource limited (i.e., increased attention will yield improvement).	The correlation between RTs in the probe alone and dual-task conditions should be lower than the reliability estimates of each.
3	Performance on the easy primary task should be unaffected by the secondary task when performed simultaneously.	Performance on the easy primary task when performed alone and when performed under dual-task conditions should not differ significantly.
4	Performance on the primary and secondary tasks under all conditions is not attributable to some general ability factor.	Correlations between probe RT alone and proportion correct on both easy and hard primary tasks should be nonsignificant.
Double		
5	Secondary measures under dual-task conditions must draw from the same general resource pool.	(a) Dual-task RTs in both conditions should be significantly correlated after having partialled out performance on the secondary measure alone. (b) Within- and cross-task partial correlations corresponding to each hard primary task should not be significantly different.

Note. Assumption 5 (double) is only tested in order to determine the cross-task, phase 2, analyses.

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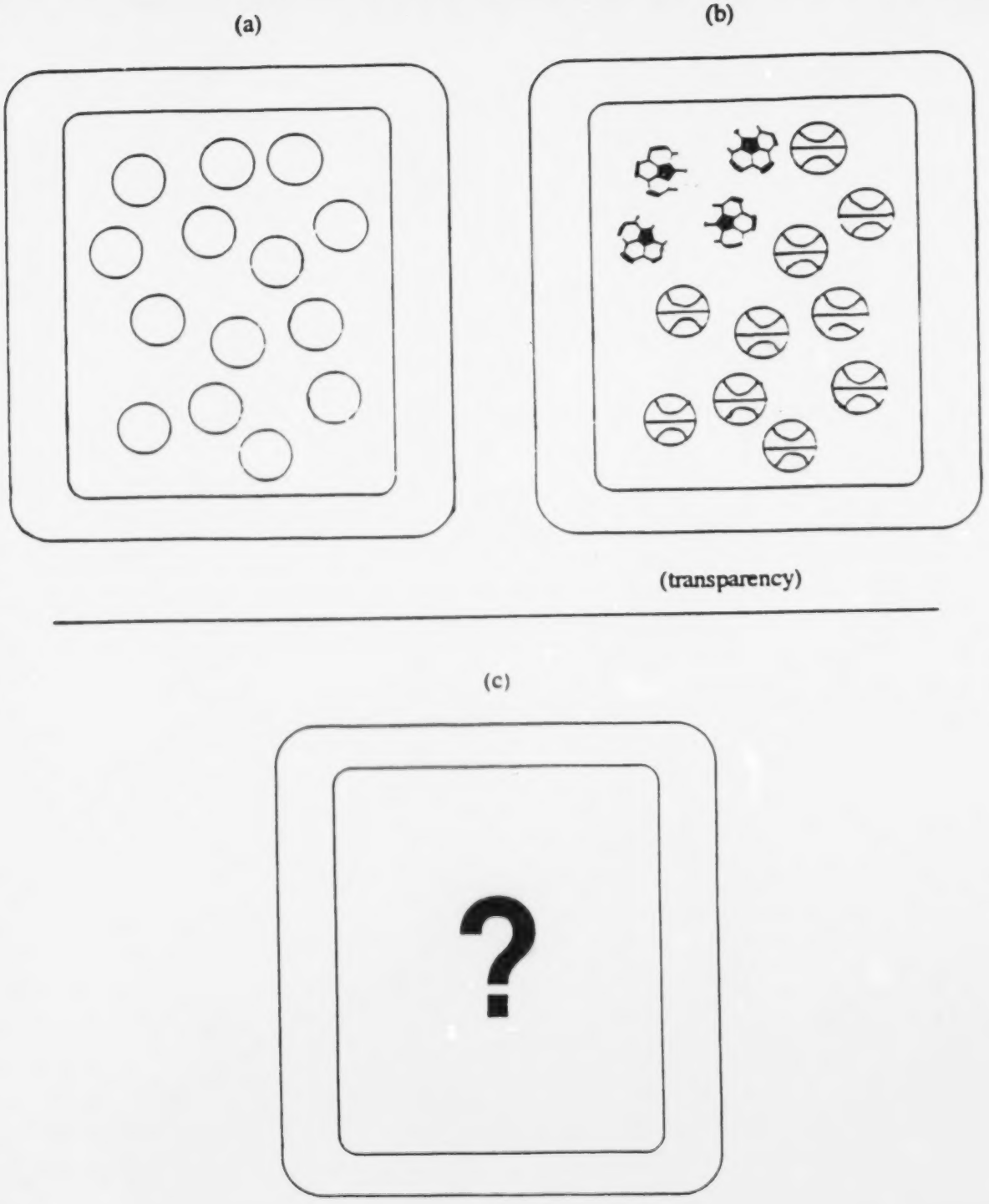

Fig. 1. Sample class inclusion problem.

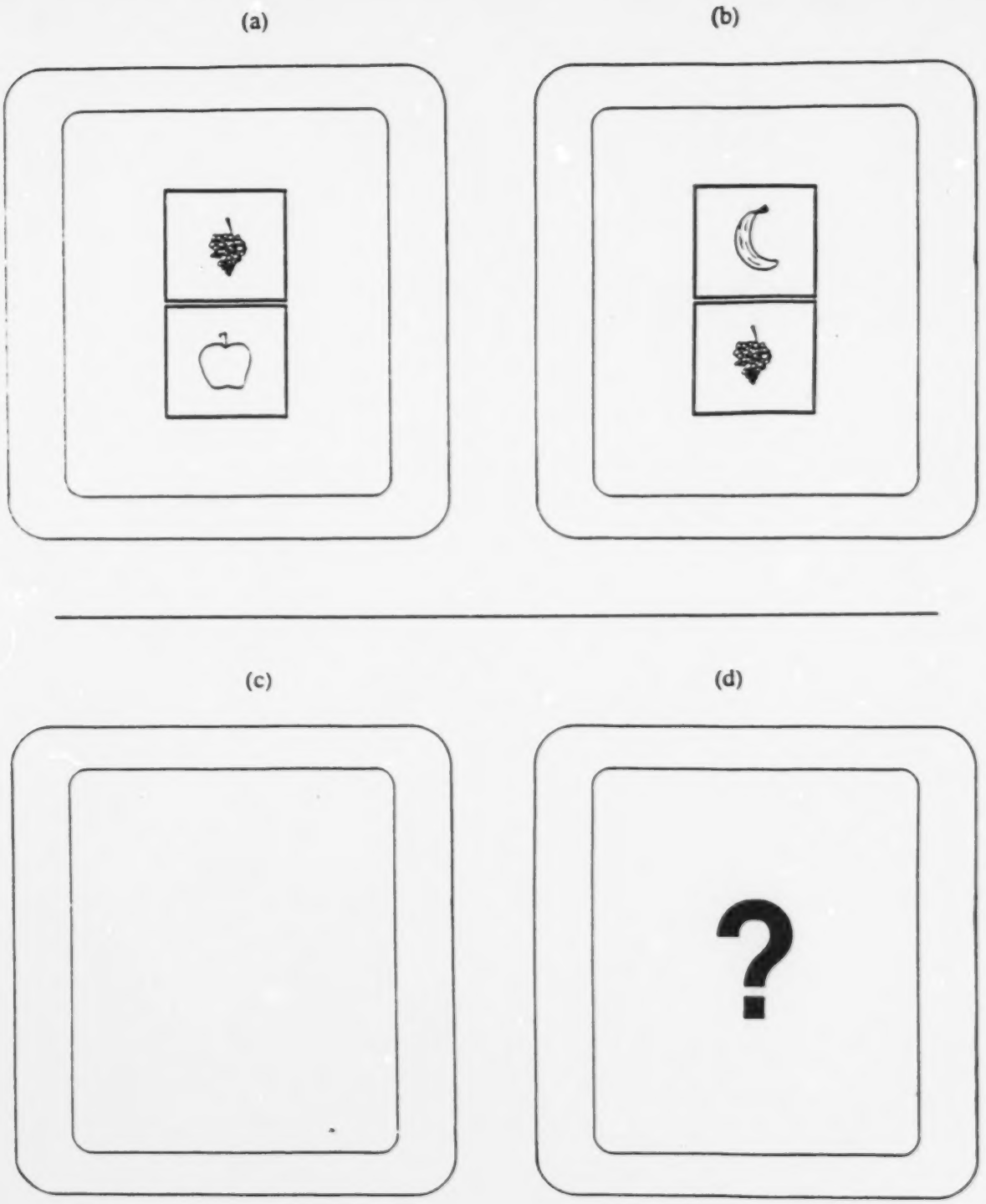

Fig. 2. Sample transitive inference problem.

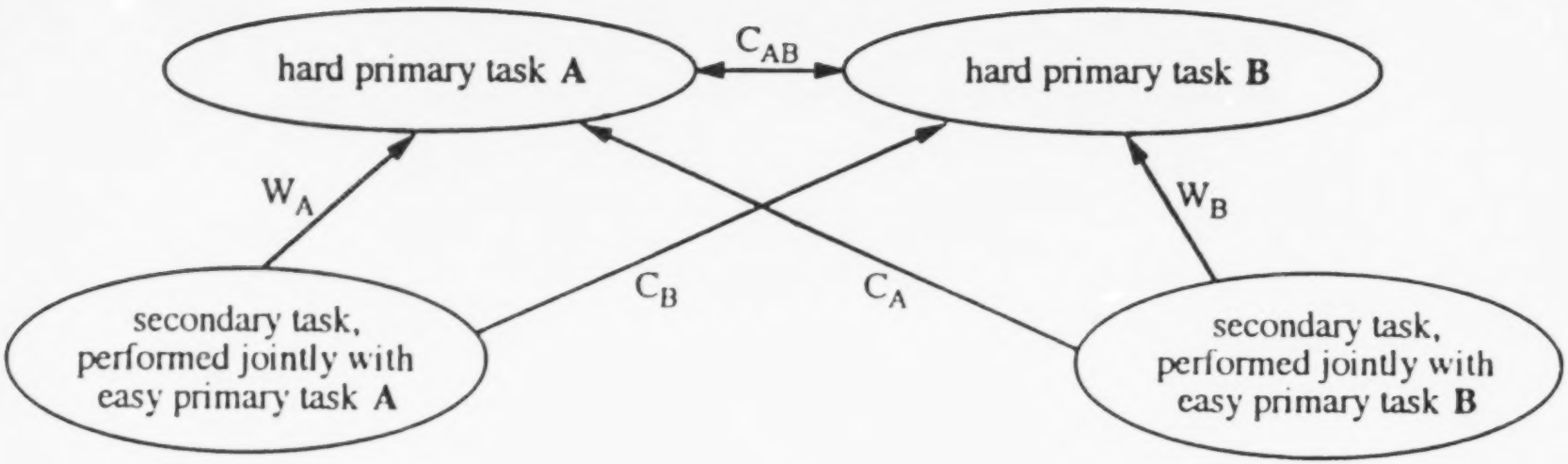

Fig. 3. The five predicted relationships emerging from use of the double easy-to-hard paradigm. W = within-task; C = cross-task. (Adapted from Halford, 1993).

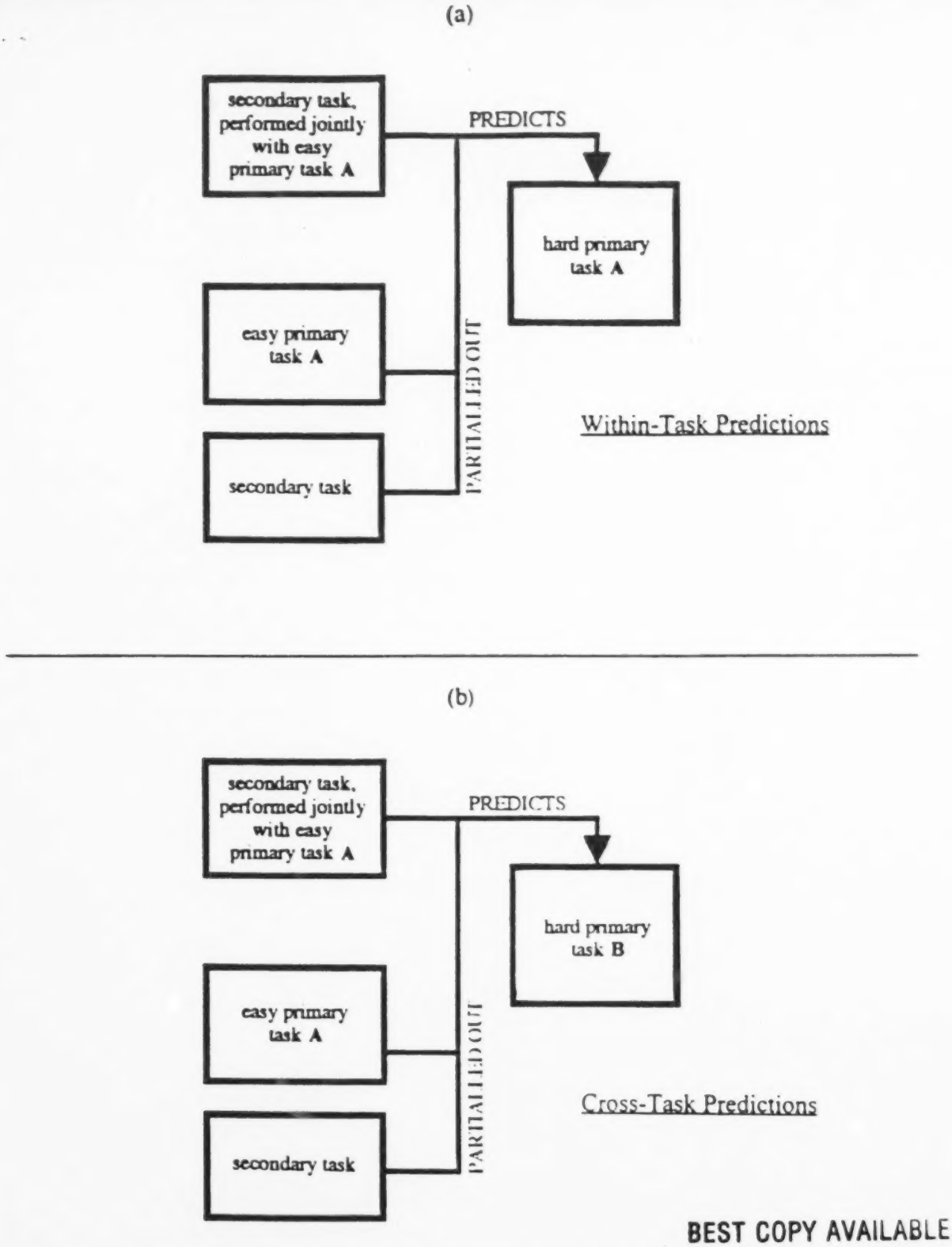

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Fig. 4. The logic of the within-task and cross-task predictions underlying the use of partial correlations.